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THE EFFECT OF SILAGE ON THE FLAVOR AND ODOR OF MILK.

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CAUSES OF TAINTS IN MILK.

Cow's milk invariably has a more or less pronounced flavor and odor, but comparatively little is known concerning the substances contributing to these characteristics. The flavors vary from those that are pleasing to the taste to others which make the milk objectionable and unpalatable. It has been observed by several investigators that regardless of the feeds used and care taken, each cow imparts to her milk a more or less pronounced individual taste. In a row of cows receiving the same feed and care, the authors have observed bitter, strong, salty, and flat milk as well as that having a very pleasing flavor. Several of these if sold alone would have been rejected

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by consumers, yet when all were blended into the mixed milk of the herd, the resulting blend was pleasing to the taste.

Flavors and odors in milk result from four causes:

1. The internal or physical condition of the individual cow.
2. Those absorbed within the body of the cow from highly flavored feeds.
3. Odors absorbed into the milk after production.
4. Bacterial development within the milk on standing.

Flavors and odors of the first and second classes are more noticeable just after the milk is drawn and usually do not increase with time. Those of the fourth class become more apparent after some time has elapsed. This bulletin considers principally the factors in Groups 2 and 3, although information regarding Group 1 is brought out by the investigation.

Milk of pleasing quality is usually produced on farms making a specialty of high-grade milk. On the other hand, the great bulk of the country's supply is produced on farms where milk production is but one of several farm activities, and, as a result, less time is available for controlling the factors which affect deleteriously the flavor and odor of milk. With the exercise of a few precautions, however, some of the defects found in market milk may at least be alleviated.

Factors affecting the flavors and odors of milk have been investigated extensively, and much excellent work pertaining to the subject published. However, such work has largely dealt with the subject in a general way. The authors of this bulletin have studied the problem from a somewhat different angle. The endeavor has been to suggest methods of assistance to the average dairyman in the production of milk reasonably free from the feed taints too frequently complained of in market milk.

The objects of this investigation therefore may be outlined as follows:

1. To determine whether or not the feeding of the different silages does affect the flavors and odors of milk.
2. If such is the case, to determine how these silages may be so fed and and the milk so handled as to minimize their effect on the quality of the product.

DESCRIPTION OF METHODS USED IN EXPERIMENTAL WORK.

For the experiments, a small barn was constructed at the United States Department of Agriculture Dairy Experiment Farm at Beltsville, Md. The building was of wooden construction throughout and was divided into two parts, one part providing space for four cows. The material used for floors, walls, and ceiling was No. 1 tongue-and-groove pine. Building paper was placed on the outside walls of the part used for a stable to make the building as free as possible from drafts. Ventilation was provided by doors and windows.

The stable contained approximately 250 cubic feet of air space for each of four cows, or about one-half the air space required by

most city regulations. The object was not only to get a milking chamber which would hold odors, but, by cutting down the space one-half, to intensify still further the degree of feed odors in the stable air. This condition was necessary during the absorption work of the investigation. The silo was at a considerable distance from this barn.

Four cows, each giving about 10 pounds of milk daily, of approximately 4 per cent butterfat, were selected from the Dairy Division herd. Only those animals which gave milk free from decided off flavors and off odors were selected and these were transferred to the small barn. The milk in all cases was drawn by milkers who gave close attention to the cleanliness of the cows and stable and of their own hands. The cows were alternated from time to time in order to equalize any abnormal results due to the milk of any individual animal. For example, in working with the first absorption phase, each pair of cows was milked outside the barn on alternate afternoons. At intervals, the individuals in each pair were interchanged.

During these experiments the cows when producing the check samples were fed on a basic grain and hay ration which did not appreciably affect the flavor and odor of the milk they produced.

In all the work, the milk from the different pairs was drawn into sterilized, covered pails, and the milk from each pair strained through filter cloth into a separate can that had been sterilized. The utensils were steamed in a sterilizer for 30 minutes, and afterwards allowed to remain there until used.

METHOD OF SAMPLING.

After milking, the two cans of milk were promptly carried from the barn to the milk room, the milk in each can stirred, and samples taken. The milk from each pair of cows was emptied into a gravity creaming can and with the samples was placed in a refrigerator which cooled and held it below 50° F. The next morning the skim milk in the different cans was drawn off and samples of the cream taken.

When the effect of aeration was studied, half of the warm milk from each pair of cows was aerated by passing it over a clean surface cooler, the milk resampled, the remainder placed in the refrigerator, the milk allowed to cream, the skim milk drawn off, and the cream also sampled.

When, in addition, it was desired to get a standard sample known to contain the flavor and odor of silage, part of the milk from the cows not fed silage and not exposed to the silage odor in the milking barn, while still warm, was redrawn through an apparatus containing the silage odor. This apparatus is shown in Figure 1. Ten pounds of silage, fresh from the silo, were placed in this closed chamber an hour before the redrawing took place.

The warm milk was poured into the funnel erected on top of this box, and redrawn through the openings into a container resting on the silage within the chamber. The odor arising from the silage in

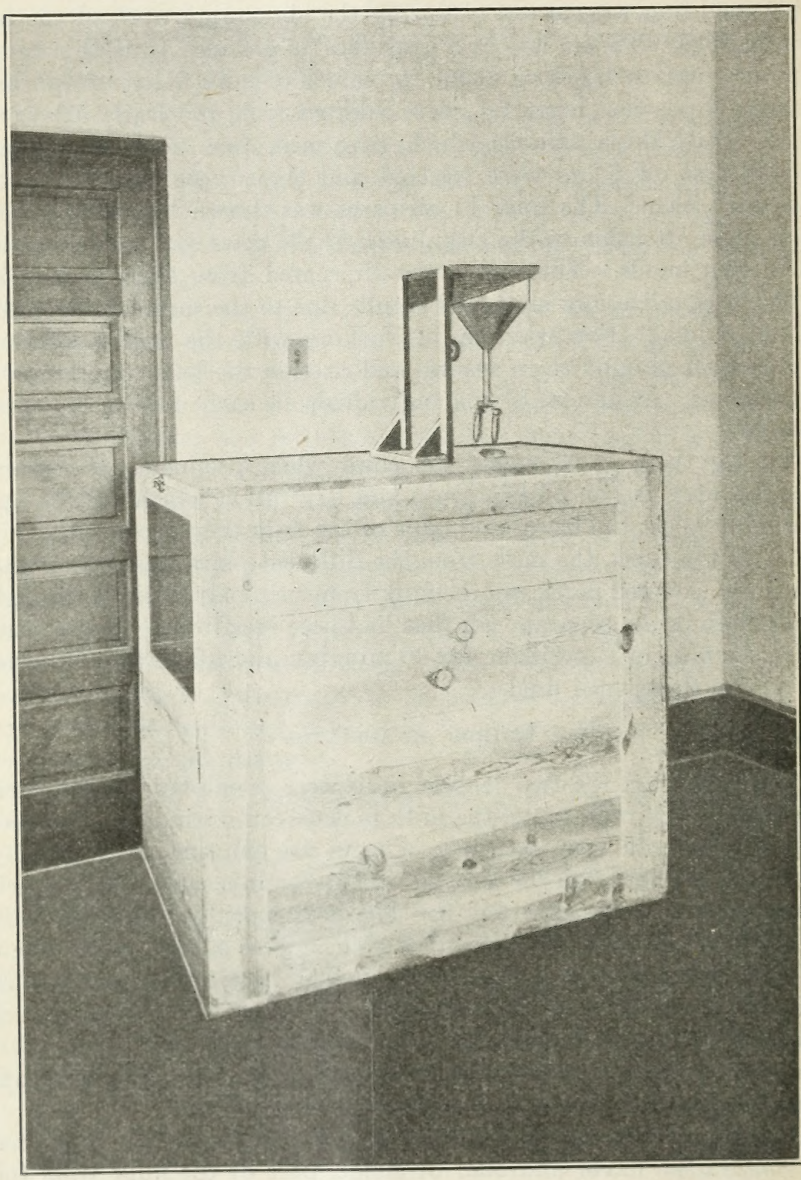

FIG. 1.—Apparatus for drawing samples of milk through atmosphere saturated with silage odor.

the closed chamber imparted to the warm milk, which was passing through it, a decided silage flavor and odor. A portion of this was drawn, cooled, and delivered with the other samples. All samples

were examined by men in the Dairy Division of the United States Department of Agriculture and members of the Dairy Husbandry Department of the University of Maryland.

METHOD OF EXAMINATION.

Flavors and odors are more apparent when the milk is at body temperature. For this reason all samples, before being submitted to the different judges, were heated in a water bath to about body temperature.

Some flavors and odors, because of familiarity, are quickly recognized by some people, and because of unfamiliarity may not be so quickly recognized by others. Standard samples of silage-flavored milk were provided to supply this information. When the portions were warmed and ready for examination, the sample containing the known silage flavor and odor was passed around and examined, so that the different men might have a measure for determining whether or not any of the other samples contained a silage flavor or a silage odor or both. Each man was furnished with slips upon which to record the flavor and odor in the different samples submitted to him. At the end of each phase of the work, the information on these slips, when compared to the key containing the history of each sample, furnished a basis for conclusions.

THE FEEDING OF SILAGE.

Ever since silage came into use as a feed for dairy cattle more or less controversy has taken place regarding its effect on the flavor and odor of the milk produced. It has frequently been said that the feeding of silage to milking cows gives rise to disagreeable flavors and odors. So much has appeared on the subject that health authorities in some cities have incorporated in their city milk laws regulations relating to the handling and sale of milk produced by cows fed silage.

EXPERIMENTS WITH CORN SILAGE.

During the first three weeks that the cows were in the specially constructed barn experiments were carried on for the purpose of determining the combination of concentrates and roughage for a basic ration which would not interfere with the flavor and odor of the milk normally produced by the cows selected for the work. When this combination had been obtained the barn and the cows were carefully cleaned.

1. EFFECT OF CORN-SILAGE ATMOSPHERE ON FLAVOR AND ODOR OF MILK.

On alternate days 2 cows were removed to the outside one hour before milking and 150 pounds of corn silage, fresh from the silo,

was spread on the platform underneath the 2 cows remaining in the stable and the doors and windows tightly closed. During the interval before milking, the silage odor so permeated the stable air that by the time milking was started a decided silage odor was present. It will be noted that the quantity of silage spread out would have been equivalent to 75 pounds per cow in an air space of approximately 500 cubic feet. Table 1 shows the result of the experiment.

Particular attention is called to the extreme condition of barn-air saturation used in this experiment. This exaggerated condition was obtained for the purpose of ascertaining whether or not the so-called silage flavor and odor might be air-borne to milk under extreme barn conditions. No legitimate excuse can be conceived for the production of milk in a barn without ventilation or with the small amount of air space used in this work to determine the above point. Manure was removed once each day and the barn thoroughly aired.

TABLE 1.—*Effect of milking in stable air saturated with silage odor.*

Result of sampling.	Cows milked in silage atmosphere.		Check cows milked in open air.	
	Milk.	Cream.	Milk.	Cream.
Number of examinations	415	415	415	415
Off flavor	96	103	51	57
No off flavor	319	312	364	358
Off odor	51	77	19	31
No off odor	364	338	396	384

One of the most interesting points brought out was that although in at least one-fourth of the cases the milk produced by the cows milked in the barn under these extreme conditions took on the off flavors and odors present in the barn air to a sufficient degree to become apparent to those looking carefully for them, it certainly did so to a less extent than is commonly supposed. The terms used in describing the off flavors and odors were, "barny," "flat," "slightly off," "off," "slightly strong," and "slight feed." It was observed that flavor and odor in the milk were designated by the matter with which they were associated. The off flavors and odors were found more often in the cream than in the milk. This would indicate that the fat of the milk absorbs off flavors to a greater degree than the milk plasma.

While off flavors were noted in approximately one-fourth of the cases, a large percentage of these were reported as "barny," "strong," and "off," with but few notations of "slight feed."

The terms used to describe the odors of the milk produced in the closed stable were the same as those used to describe the flavors, except that the terms "barny" and "musty" were used more often.

From this work it is apparent that under these extreme conditions, not approached on dairy farms, the silage flavor and odor may, to a limited extent, be air borne to milk during production.

"Natural," "normal," "good," and "excellent" were the terms used in describing the flavor and odor of the milk produced outside of the stable by the check cows in almost 90 per cent of the cases. In 45 out of 415 examinations, "slightly flat," "flat," "slightly salty," "slightly off," and "off" were used, and in 6 cases the term "slight feed." All these terms except the last are employed in describing what are known as individual flavors. If we assume that a like number of the 96 off flavors in the milk produced inside the stable were also individual taints, this would reduce the possible number affected by the barn air in Table 1 to 51 samples out of 415, leaving 364, or close to 90 per cent, which did not absorb sufficient silage odors during the milking in the closed stable to be discernible to those looking carefully for such flavors.

2. FEEDING CORN SILAGE BEFORE MILKING IN UNVENTILATED BARN.

Having determined the effects of an intense silage atmosphere on the flavor and odor of milk under the extreme conditions which prevailed in Experiment No. 1, the next step was to determine the effects under extreme conditions on the farm. In this experiment the air saturation arose from the silage which was fed to the cows in the barn. The cows were given all the corn silage they would consume, each cow receiving from 30 to 50 pounds in two feedings—one hour before milking in the morning and one hour before milking at night. The barn doors and windows were closed after each feeding. During this experiment the milk and cream samples were examined by 39 different men.

TABLE 2.—*Effect of feeding 15 to 25 pounds of corn silage per cow before each milking in an unventilated barn.*

Result of sampling.	Cows fed silage.		Check cows not fed silage.	
	Milk.	Cream.	Milk.	Cream.
Number of examinations	346	346	346	346
Off flavor	313	315	30	30
No off flavor	33	31	316	316
Off odor	318	317	29	30
No off odor	28	29	317	316

In almost 90 per cent of the cases the terms used in describing the flavors present in the milk from cows fed silage were "very slight feed," "slight feed," "feed," "strong feed," "sweet," "fermented," "malt," "slight silage," and "silage." From this it is apparent that

when from 30 to 50 pounds of silage were fed daily to cows in two feedings, one hour before each milking, in an unventilated barn, a feed flavor and odor were imparted to the milk of the cows receiving silage.

The flavors and odors in the milk and cream from the alternate cows not receiving silage were usually described as "good," "excellent," "mild," "natural," and "normal." The milk from the cows not fed silage furnished a check on the effects of the odors present in the barn air. Table 2 shows conclusively that when cows were kept in an unventilated barn in which the corn-silage odor was present to a greater degree than under reasonably good farm feeding conditions the examiners, looking painstakingly for such, did not find a feed flavor and odor except in a comparatively few cases. These were silage taints probably due to carrying over such taint within the body from previous feeding, as demonstrated in subsequent experiments. These results show that the more or less common opinion that silage flavors are air-borne to milk is not true to the degree commonly supposed. They also show that milk from cows fed silage under the conditions of this experiment does take on, through the body, the silage flavor and odor.

3. FEEDING 10 POUNDS OF CORN SILAGE BEFORE MILKING.

Having determined that the odor of corn silage is usually body-borne to milk, the next step was to ascertain the number of pounds of corn silage which could be fed to cows one hour previous to milking before such milk would take on sufficient silage flavor and odor through the body to be recognized by those looking carefully for the same. Table 3 shows the result from samples drawn from the mixed milk of cows each receiving 10 pounds of silage. The barn was well ventilated in this and all experiments which follow.

TABLE 3.—*Effect of feeding 10 pounds of corn silage per cow once a day one hour before milking.*

Result of sampling.	Milk from cows fed silage.		Milk from cows not fed silage.
	Before aeration.	After aeration.	
Number of examinations	51	51	51
Off flavor	44	38	2
No off flavor	7	13	49
Off odor	41	35	2
No off odor	10	16	49

The flavors and odors of milk from the cows fed silage were described as "slight feed," "sweetish feed," or "silage." These results show that the feeding of 10 pounds of corn silage to cows one hour before milking gave the milk a sufficient feed flavor to be recog-

nized in over 85 per cent of the cases. Although sufficient flavor and odor were present in the milk to be detected in this number of cases by men examining the milk carefully, it is probable that the feeding of 10 pounds of silage, as above, did not affect the milk sufficiently to be noted by the average consumer.

EFFECT OF AERATION.

To determine the effect of aeration on the feed flavor and odor present, the same milk, after being sampled and while still warm, was passed over a surface cooler and resampled. The results in Table 3 show that when the milk was aerated a part of the feed flavor and odor it contained was removed. The table shows that, in the aerated milk, feed flavors and odors were noted in six samples fewer than in the milk before aeration. They were reduced in degree also in the other samples.

The cows not receiving silage occupied and were milked in alternate stalls from those receiving silage. In the table it is seen that in over 96 per cent of the cases no feed flavor or odor was observed in the milk drawn from cows standing in the same barn side by side with the cows fed silage.

This experiment shows that the feeding of 10 pounds of corn silage one hour before milking gave a perceptible feed flavor and odor to the milk. It further shows that if such milk is carefully aerated while still warm, the degree of flavor and odor may be materially diminished. In the opinion of the judges, the silage flavor present in the milk often enhanced rather than detracted from its palatability.

4. FEEDING 20 POUNDS OF CORN SILAGE BEFORE MILKING

In the next experiment, the quantity of corn silage fed before milking was increased to 20 pounds.

TABLE 4.—*Effect of feeding 20 pounds of corn silage once a day one hour before milking.*

Result of sampling.	Milk from cows fed silage.		Milk from cows not fed silage.
	Before aeration.	After aeration.	
Number of examinations	25	25	25
Off flavor	18	18	0
No off flavor	7	7	25
Off odor	25	20	0
No off odor	0	5	25

The results in Table 4 show that the feeding of 20 pounds of corn silage each to cows one hour before milking gave the milk sufficient feed flavor or odor to be detected in all of the samples. The flavors

and odors present were described as "slight feed," "feed," "silage," and "strong feed."

During the latter part of this experiment it became necessary to use silage which had been in the silo for four or five years. This silage had a milder flavor than the 8-month-old silage fed in 10-pound lots during the previous experiment, and gave the milk a milder silage flavor. This suggests that the degree of odor present in the silage helps to determine the degree of feed flavor and odor imparted to milk.

EFFECT OF AERATION.

After the samples of milk from the silage-fed cows were taken, the remaining milk, while still warm, was aerated by passing it over a surface cooler. Although diminished by aeration, the feed odor was still present in sufficient degree to be noted in over 70 per cent of the flavor examinations and in 80 per cent of the odor examinations.

Table 4 also shows the conditions noted in the check samples from cows not fed silage. The terms used by the judges in describing the flavor and odor in these samples were "natural," "normal," "good," and "excellent." In no cases were the judges able to detect any feed flavor or odor in the milk drawn from the cows not receiving silage. This agrees with previous work covering this phase.

It is apparent that feeding 20 pounds of corn silage one hour before milking does affect the flavor and odor of milk to an appreciable extent. It is also apparent that aeration diminishes the degree of the feed odor imparted by the silage. The experiment further suggests that when 20 pounds of 5-year-old silage are fed, sufficient will pass through the body to affect the taste and smell of the milk produced. While the feed flavor and odor in this milk were sufficiently prominent to be apparent to some consumers, it was the opinion of the judges that after aeration it would be accepted in a great many cases without complaint on the part of the consumer.

5. FEEDING 30 POUNDS OF CORN SILAGE BEFORE MILKING.

The quantity of silage was next increased to 30 pounds per cow.

TABLE 5.—*Effect of feeding 30 pounds of corn silage once a day one hour before milking.*

Result of sampling.	Milk from cows fed silage.		Milk from cows not fed silage.
	Before aeration.	After aeration.	
Number of examinations	46	46	46
Off flavor	46	46	1
No off flavor	0	0	45
Off odor	46	46	1
No off odor	0	0	45

The flavors and odors in the milk of the silage-fed cows were noted as "fermented feed," "feed," or "slight silage," "silage," or "strong feed" in all cases. The results in Table 5 show that milk from cows fed 30 pounds of corn silage before milking had a decided feed flavor and odor. The taste and smell of the feed were noted in every case by all the judges. In the opinion of these men, sufficient was present to be noted by even those consumers giving but little attention to the flavor and odor of the milk supplied them.

EFFECT OF AERATION.

Although a feed flavor and odor were noted by all the men who passed upon the aerated milk, the degree present was diminished. This shows that when silage is fed in these quantities just before milking, aeration may be of much assistance in decreasing the flavor and odor of silage.

The milk from the other 2 cows in the barn in alternate stalls from those fed silage was examined as a check on the barn air and the basic ration which all the cows were receiving.

Comparing the results in this experiment with those obtained in Experiment No. 2, the effect of the new factor, ventilation, on the flavor and odor of milk produced by cows not fed silage is strikingly shown. (Compare the columns for the check cows in Tables 2 and 5). Proper ventilation may play an important part in ridding the barn of manure odors. Adequate ventilation is, therefore, important in limiting undesirable flavors and odors which may be absorbed during milking.

This experiment also shows that feeding 30 pounds of corn silage one hour before milking gives the milk a feed flavor and odor sufficient to render it objectionable to most consumers. Another point brought out was that, whether silage is fed immediately after being taken from the silo or allowed to air somewhat before feeding, the milk produced carries strong feed flavor and odor. This feed flavor and odor had a tendency, however, to be stronger in the milk when the silage was fed fresh from the silo. Even when as low as 10 pounds of silage per cow were fed a silage flavor was imparted to 85 per cent of the samples in a sufficient degree to be noted by those looking carefully for it. The degree of flavor, however, was much less than when 20 or 30 pounds were fed in a like manner. It may be said that not until 20 pounds or more were fed did the feed flavor and odor become so pronounced as to make the milk decidedly objectionable to a majority of consumers. In fact, it was the opinion of the judges that the flavor imparted when 10 pounds of corn silage were fed enhanced the palatability of the milk.

It was apparent that the greater the quantity of silage fed before milking the more pronounced the feed flavor and odor. The ob-

servers noted that aeration diminished the degree of silage flavors and odors to a greater extent as the quantity of silage fed was increased.

6. FEEDING CORN SILAGE AFTER MILKING.

The practice of feeding silage after milking is recommended by practically all authorities. The next step in this work was to determine the quantity of corn silage that could be fed after milking and not deleteriously affect the flavor and odor of the milk produced. Two of the cows were fed all the corn silage they would consume in two feedings per day one hour after milking. One of these individuals refused more than 30 pounds or 15 pounds at a feeding, while the other readily consumed 50 pounds in two feedings of 25 pounds each. The milk from these cows, when mixed, represented an average consumption of 40 pounds of silage per cow each day.

TABLE 6.—*Effect of feeding 15 to 25 pounds of corn silage twice daily one hour after milking.*

Result of sampling.	Milk from cows fed silage.		Milk from cows not fed silage.
	Before aeration.	After aeration.	
Number of examinations	25	25	25
Off flavor	15	2	1
No off flavor	10	23	24
Off odor	12	2	1
No off odor	13	23	24

The results in Table 6 show that when an average of 20 pounds of corn silage per cow was fed just after each milking the milk took on a slight feed flavor or odor in more than 50 per cent of the cases. The flavor and odor detected were described as "slight feed" and "slight silage." This shows that while the feeding of corn silage after milking is to be recommended, such a practice does affect both flavor and odor when fed under conditions similar to those prevailing in this experiment. It appears also that while men accustomed to examining milk closely detected a slight feed flavor and odor, it was present in quantities too small to be objectionable to the average consumer, as 40 per cent of the samples did not show these characteristics sufficiently to be detected when the milk was carefully examined by experienced men.

It is interesting also to note that in the opinion of the majority of the judges, the slightly sweetish flavor imparted enhanced rather than detracted from the palatability of the milk. In no case were the feed flavors and odors present to as great a degree as was found in the samples from cows fed 10 pounds of silage one hour before milking.

EFFECT OF AERATION.

This milk was afterwards aerated, resampled, and examined. After aeration, instead of 50 per cent of the samples containing a recognizable feed flavor and odor, it was observed in less than 10 per cent of the samples. From this we may conclude that careful aeration of the warm milk from cows fed up to 20 pounds of silage, twice daily after milking, will materially reduce the degree of feed flavor present. Cows are usually fed less than 50 pounds per cow per day. If this is fed after milking, and the milk carefully aerated, it is probable that the feed flavors and odors present will be so slight as to be passed by the average consumer without observation. It must be recognized, however, that this work was done with carefully made silage. It is also probable that the sudden feeding of corn silage in quantities as great as 40 pounds a day to a cow not accustomed to receiving it might have a more decided effect on the flavor and odor of milk for the first few days, or until the cow's stomach became accustomed to handling this quantity. It was noted that as each phase of the work with silage progressed the feed flavor and odor were detected less frequently by the judges, even though the same quantity was fed from day to day.

As a check on the cows fed silage, the milk from the other pair standing side by side was sampled. The flavors and odors of these check samples, with one exception, were described as "normal," "natural," "mild," "good," and "excellent."

EFFECT OF CONDENSING ON SILAGE-FLAVORED MILK.

Ten gallons of milk from cows not receiving silage was passed through a saturated silage atmosphere in the apparatus shown in Figure 1. This gave the milk a more decided silage flavor and odor than was observed when silage was fed even under the extreme conditions of Experiment No. 2. The milk was then condensed in a commercial apparatus and the resultant product sampled.

In the early days several large firms buying milk for condensing purposes discriminated against milk from cows fed corn silage. This examination was conducted to secure information on the effect of silage on condensed milk. It was noted by all the judges that the distillate taken from the silage milk during condensing contained a concentrated silage flavor and odor, much more so than the milk itself before condensing. It was noted also that the condensed milk had much less silage flavor and odor than the milk from which it was manufactured.

FEEDING SPOILED SILAGE.

Dairymen are frequently warned by authorities not to feed spoiled silage because of its effect on the milk flavor. Experiments were

carried on with the feeding of decomposed silage taken from the top of a silo when it was opened. From 5 to 15 pounds of this material were fed to each cow one hour before milking. It was noted that 5 pounds of this imparted a very strong flavor and odor to the milk, described as "resembling garlic" by several of those who passed upon it. As much as 15 pounds of this material was eaten readily by the cows under experiment. Even after aeration it was found that when the quantities fed were as low as 5 pounds, sufficient of the objectionable flavors and odors remained to render the milk objectionable to the consumer.

DISCUSSION OF CORN-SILAGE EXPERIMENTS.

It is apparent that under the feeding conditions in these experiments the danger of tainting milk during production by exposure to stable air containing the odor of silage is not so important as some have stated. It is shown, however, that ventilation plays an important part in preventing the tainting of milk during milking, and, further, that milk should be removed from the stable immediately after it is drawn. Statements have been made, and possibly it has been the general belief, that the greatest source of silage flavors and odors in milk is silage-tainted barn air. These experiments show that silage flavors and odors are almost wholly taken up by the milk within the body of the cow. Whether silage is fed before or after milking, the barn should be carefully ventilated before milking is started.

In the feeding of silage before milking, these experiments show that when as little as 10 pounds to a feed was given, the milk took on through the body of the cow a faint feed flavor and odor. As the quantity was increased to 30 pounds at a feed, the degree of silage flavor and odor was likewise increased. It is also shown that careful aeration materially reduced the degree of both feed flavor and odor.

This confirms the work of Knisely (*8*[1]) who reports that milk from cows fed corn silage has a more pronounced odor than milk from cows fed hay. King (*7*) also states:

> It was demonstrated beyond question that when silage is fed a short time before milking, a sweetish odor is imparted to milk.

An article in Hoard's Dairyman (*1*) states:

> If silage is fed before milking, there is likely to be a silage odor in the milk.

Many other workers have also pointed out these truths during the last 20 years.

In the feeding of silage after milking, our results do not entirely agree with some other workers. It was found that when as little as

[1] The italic figures in parenthesis refer to Literature Cited at end of bulletin.

30 pounds daily was fed in two feeds after milking, the milk from the cows showed a slight feed flavor and odor, and that when more than 40 pounds per day were fed to cows, their milk carried continuously a slight silage flavor and odor. In this connection, it is again pointed out as reported by Henry and Morrison (*6*), that as feeding progressed the effects of the silage become less and less apparent in the milk. In our work it was found that while this was true when less than 35 pounds per day was fed to each cow, it was shown that when over 40 pounds were consumed, the sweetish feed flavor could always be detected. King (*7*) reports:

> It was demonstrated that if silage is fed to cows just after milking, in a majority of cases, milks so produced could not be separated by the sense of smell from nonsilage milks.

Farrington (*3*) reports:

> It has been repeatedly proved that silage can be fed to dairy cows without tainting the milk, butter, or cream in the slightest.

The presence of a small but discernible amount of silage flavor in milk need not perplex, however, for it is shown that careful aeration will reduce this to a point where the feed flavor and odor will not be detected by the average consumer.

Moderate quantities of corn silage properly fed to milking cows have a tendency to enhance rather than to detract from the flavor and odor of the milk. This is especially true of individual milks normally flat or lacking in flavor.

EXPERIMENTS WITH ALFALFA SILAGE.

It frequently happens that farmers have difficulty in curing alfalfa for hay. The first cutting is sometimes so full of weeds that it dries slowly; in other cases a wet season interferes, while at other times a threatening early frost makes immediate cutting of the last crop expedient. Putting the green alfalfa into the silo has in many cases meant saving the crop.

While some dairymen have used alfalfa silage with success, others claim that milk spoilage is experienced. However that may be, a great deal of alfalfa silage is now being fed. The experiments next described were carried out to determine how this roughage, rich in protein, may be fed so as to affect least deleteriously the flavor and odor of the milk produced.

The alfalfa silage used was made from finely cut green alfalfa, carefully packed in the silo.

1. FEEDING ALFALFA SILAGE BEFORE MILKING.

The first work covered the feeding of 5 pounds of alfalfa silage one hour before milking. This quantity was gradually increased to

20 pounds per cow. The cows on experiment would not consume more than this weight at a feeding.

TABLE 7.—*Effect of feeding 5 to 20 pounds of alfalfa silage once daily one hour before milking.*

Result of sampling.	Milk from cows fed silage.		Milk from cows not fed silage.
	Before aeration.	After aeration.	
Number of examinations	11	11	11
Off flavor	11	11	0
No off flavor	0	0	11
Off odor	11	11	0
No off odor	0	0	11

The results in Table 7 show that the feeding of alfalfa silage to cows one hour before milking imparted a feed flavor which could be detected in all cases. The off flavors were described as "slight feed," "feed," "slight silage," and "alfalfa silage" as the quantity was increased up to 20 pounds. The odors were described with the same terms. When the milk from the cows receiving 5 pounds was aerated the flavor and odor were very faint. When 10 pounds per cow was reached, the milk contained sufficient feed flavor and odor even after aeration to be ordinarily detected by consumers. When 15 pounds had been reached sufficient was present, in the opinion of the examiners, to cause rejection of the milk by the average consumer. Without question, the cream from this milk would be rejected by the sweet-cream trade.

EFFECT OF AERATION.

In this experiment it was noted that while aeration removed a great part of the feed taste and aroma, sufficient remained to be noted in all examinations.

Standing in the barn in alternate stalls were the cows which did not receive alfalfa silage. It is seen in the table that no feed flavor or odor was noted in the milk produced by these cows. It is to be remembered, however, that throughout this work, with the exceptions of Experiments Nos. 1 and 2, the barn was well ventilated.

2. FEEDING ALFALFA SILAGE AFTER MILKING

As in the feeding of corn silage the importance of feeding alfalfa silage only after milking has been noted. To determine how much of this may be fed per cow, after milking, without rendering the milk objectionable to consumers, the following work, shown in Table 8, was carried on.

TABLE 8.—*Effect of feeding 5 to 20 pounds of alfalfa silage once daily one hour after milking.*

Result of sampling.	Milk from cows fed silage.		Milk from cows not fed silage.
	Before aeration.	After aeration.	
Number examinations	14	14	14
Off flavor	10	5	0
No off flavor	4	9	14
Off odor	8	5	0
No off odor	6	9	14

In this experiment 5 pounds were fed to begin with, and this quantity increased 5 pounds every two days up to 20 pounds, when it was reduced to 5 pounds again, dropping 5 pounds every two days. It was observed that the alfalfa-silage flavor did not become noticeable in the milk until 10 pounds or more were fed. However, when from 15 to 20 pounds were consumed at each feeding the milk took on a decided feed flavor and odor.

When this milk was aerated the degree of feed flavor and odor was decidedly reduced and was detected less often, as shown in the table. This again shows the importance of aerating milk. It was also observed that when the milk from cows receiving 10 pounds was aerated all judges failed to detect feed flavors or odors.

This work indicates that alfalfa silage should be fed only after milking, and that the milk should be well aerated while still warm. The importance of this is shown by comparing the results in Table 7 with those obtained in Table 8.

EXPERIMENTS WITH SWEET-CLOVER SILAGE.

In some cases clover crops have been made into silage with fair success. Where weather conditions interfere with the proper curing of clover for hay it is sometimes put into the silo. It is well known that the silage made from clover has a strong odor, necessitating careful feeding to avoid tainting the milk. For this experiment silage made from sweet clover, cut in fine lengths and tramped solidly, was fed to the experimental cows. It was noted that the sweet-clover silage had a more decided odor than the alfalfa silage.

1. FEEDING SWEET-CLOVER SILAGE BEFORE MILKING.

At the beginning of the work 5 pounds of sweet-clover silage were fed one hour before milking. This was continued for several days; afterwards the quantity was increased to 10 pounds and continued for several days longer; then increased to 15 pounds. An effort was

made to increase the feeding to 20 pounds, but the cows refused to consume that quantity at a feed. It was noted that even when 5 pounds were fed in nearly all cases the milk had a detectable feed flavor and odor, and when the quantity was increased to 15 pounds the feed flavor and odor became very objectionable.

TABLE 9.—*Effect of feeding 5 to 15 pounds of sweet-clover silage once daily one hour before milking.*

Result of sampling.	Milk from cows fed silage.		Milk from cows not fed silage.
	Before aeration.	After aeration.	
Number of examinations	30	30	30
Off flavor	28	20	0
No off flavor	2	10	30
Off odor	29	21	0
No off odor	1	9	30

EFFECT OF AERATION.

When the milk from the cows fed up to and including 15 pounds before milking was aerated, the intensity of the feed flavor and odor was diminished, as shown in the table. In the opinion of the judges sufficient of the feed flavor and odor had been removed during aeration to render the milk palatable.

This experiment shows that even as little as 5 pounds of sweet-clover silage, when fed before milking, produced a feed flavor; 10 pounds produced a decided feed flavor and odor, and 15 pounds so increased the intensity as to render the milk, if unaerated, objectionable to the average consumer. It is also shown that aeration so reduced the flavor and odor present, when 5 pounds were fed, as to cause it largely to disappear. When 10 pounds were fed and the milk aerated, the sweet-clover silage flavor and odor persisted. When 15 pounds were fed and the milk aerated, while the flavor and odor was somewhat stronger, a decided reduction in the degree had taken place. In the case of this silage, the odor, after aeration, seemed more tenacious than the flavor.

In this experiment, as in others, check results were obtained with alternate cows not fed silage. There was a total lack of feed flavor and odor in the milk from these cows.

2. FEEDING SWEET-CLOVER SILAGE AFTER MILKING.

The next experiment was carried on to ascertain the quantity of sweet-clover silage that could be fed after milking and the methods of handling necessary to overcome the objectionable effects.

TABLE 10.—*Effect of feeding 5 to 15 pounds of sweet-clover silage once daily one hour after milking.*

Result of sampling.	Milk from cows fed silage.		Milk from cows not fed silage.
	Before aeration.	After aeration.	
Number of examinations	30	30	30
Off flavor	28	20	2
No off flavor	2	10	28
Off odor	29	21	2
No off odor	1	9	28

The results with unaerated milk show that when sweet-clover silage was fed after milking in quantities from 5 to 15 pounds, a feed flavor and odor were imparted to the milk. In explanation of this table it may be said that in 2 cases there were no feed flavors and in 1 case no feed odor when 5 pounds were fed. When this quantity was increased to 10 pounds, the notations were, "slight silage," and "slight feed"; when 15 pounds were fed the samples were marked "feed," "strong feed," and "clover silage." While the feeding of sweet-clover silage is a desirable practice from an economic standpoint, the above results show that even when fed under ideal conditions it affected the flavor and odor of the milk produced. 15 pounds, fed after milking, tainting the milk sufficiently to be noted by the average consumer.

EFFECT OF AERATION.

Aeration, however, produced a marked change in the degree of the flavors present. By sprinkling the grain ration on the sweet-clover silage, each cow consumed up to 15 pounds of silage at a feeding. When this milk was aerated, in the opinion of the judges, the feed flavor was sufficiently diminished to be unobjectionable to the average consumer. These results show that sweet-clover silage should be fed only after milking, and the milk should be carefully aerated while still warm. When this is done, up to 15 pounds at each feeding may be fed per cow without permanently injuring the commercial value of the product.

EXPERIMENTS WITH SOY-BEAN SILAGE.

Another protein roughage, soy beans, is also sometimes ensiled. When put in the silo alone soy beans make rank-smelling silage. The effect of this feed on the flavor and odor of milk is shown in the following experiments.

1. FEEDING SOY-BEAN SILAGE BEFORE MILKING.

In feeding this material it was noted that 5 pounds gave the milk a detectable feed flavor and odor. As the quantity was increased to 15 and 20 pounds, the flavors and odors present increased in intensity.

TABLE 11.—*Effect of feeding 5 to 20 pounds of soy-bean silage once daily one hour before milking.*

Result of sampling.	Milk from cows fed silage.	Milk from cows not fed silage.
Number of examinations	16	16
Off flavor	16	1
No off flavor	0	15
Off odor	16	2
No off odor	0	14

The milk from cows not receiving soy-bean silage was scored, as usual, for a check, with the results shown in the table.

2. FEEDING SOY-BEAN SILAGE AFTER MILKING.

In feeding 5 to 20 pounds of soy-bean silage one hour after milking, it was noted that when the quantity fed reached 10 pounds, a slight flavor resulted. This was increased in degree as the quantity of silage given the cows was increased.

Aeration greatly reduced the objectionable flavor, although the extent of the reduction is not shown in the table. When the quantity fed after milking was again reduced to 10 pounds, a slight feed odor was noted by the judges after aeration.

TABLE 12.—*Effect of feeding 5 to 20 pounds of soy-bean silage once daily one hour after milking.*

Result of sampling.	Milk from cows fed silage.	Milk from cows not fed silage.
Number of examinations	16	16
Off flavor	12	0
No off flavor	4	16
Off odor	12	0
No off odor	4	16

Again it is shown that the cows not receiving soy-bean silage, standing in alternate stalls, produced milk not affected by the barn air.

From the experiments with soy-bean silage it is apparent that when this feed is fed one hour before milking, even in such small amounts as 5 pounds per cow, it affects the flavor and odor of the milk. Increasing the quantity fed increased the feed flavor. It is

evident that the proper way to feed this silage is after milking and, further, that even when so fed in quantities from 5 to 20 pounds at a feeding, most of the milk produced has a strong soy-bean silage flavor and odor.

DISCUSSION OF LEGUME-SILAGE EXPERIMENTS.

The legume silages fed in this work were unusually dark in color and had rank characteristic odors. The experiments show that they should be fed only after milking and then in quantities of not more than 15 pounds to a feed if milk reasonably free from feed taints is to be obtained.

Henry and Morrison (*5*) report that, "as a class, the legumes have proved disappointing for silage when ensiled alone." They state further (*4*) that while alfalfa has been ensiled with entire success, "often poor, vile-smelling silage is produced." In regard to soy-bean silage, Woll and Humphrey (*11*) went so far as to say that satisfactory dairy products could not be made when cows were fed this silage. Woodward and McNulty (*12*) report that silage made from clover, while palatable, has an objectionable odor necessitating care in feeding to avoid tainting the milk.

PART PLAYED BY AERATION IN REDUCING SILAGE FLAVORS AND ODORS.

Silage is a palatable, wholesome feed for milking cows, the feeding of which is generally conducive to economical milk production, and it will continue to be fed on an increasing number of dairy farms as its feeding value becomes more generally recognized. Legumes likewise will continue to be grown and fed in increasing amounts for much the same reason. Efforts will be made to save the crop by ensiling just so long as wet seasons prevent its being cured into hay, or when early frosts threaten its growth. In accordance with the method of feeding practiced by busy dairymen, corn and legume silages will continue to be fed both before and after milking. Thus cows that eat pasture weeds, such as garlic and ragweed, or are fed silage, cabbage, or turnips before milking will continue to give tainted milk. The milk from cows kept during certain seasons of the year in unventilated, sometimes unclean, barns will continue to be tainted. These feeding and barn conditions are still more general than they should be, and, until they are corrected, the milk should be taken from the stable as soon as drawn and aeration more generally employed in removing immediately as much of these taints as possible while the milk is still warm. The experiments have shown that this can be done easily and with beneficial results.

The process consists in bringing milk in thin streams into contact with the air, thus permitting the escape of the volatile taint-bearing

substances. As ordinarily practiced, aeration has a double purpose—first, to air the milk; and second, to lower its temperature. Russell (*10*) reports "the method certainly has no disadvantages." It should be borne in mind also that feed and barn taints once removed are removed permanently by the process. Marshall says (*9*) "it is best accomplished immediately after milking." According to Ernst (*2*), "the aeration of milk permits the escape of carbonic acid, hydrogen, and sulphid of hydrogen, and supplies the milk with air so that in all probability the development of certain bacteria is checked, which otherwise, if the milk had been filled in containers in a warm and unaerated condition, would have imparted to the milk a sharp disagreeable taste and odor; the milk would have been 'smothered.'"

PLACE TO USE THE AERATOR.

In aerating milk it should be borne in mind that the same conditions which favor the escape of odors which the milk contains when drawn from the cow are also conditions which permit the milk to become tainted with odors from the outside. For this reason, aeration should take place in a milk room in which the air is free from bad taints or dust, and which is well ventilated.

GOOD FLAVORS AND ODORS IN MILK.

It is important that milk have a good flavor and a good odor. It is probable that some flavors and odors constantly present in milk in time cease to be objectionable to the individual and are taken as a matter of course. In some alfalfa sections of the United States the so-called alfalfa taste is general in milk and in these sections is accepted without comment.

The work has shown that fine-flavored milk is an individual characteristic of some cows. It may be that whole herds of cows giving milk of desirable flavor will be assembled in the future, and the effort made to fix and perpetuate this desirable characteristic by breeding and selection.

Preventive measures are always best; therefore dairymen should endeavor, first, to have cows and barns clean; second, to have cow stables properly ventilated; third, to feed after milking those materials likely to taint milk; and fourth, to decrease feed and barn taints by proper and immediate aeration. Finally, prompt cooling and storing of milk at a low temperature will retard the development of odors from bacterial action.

As stated before, the cows used in these experiments produced daily approximately 10 pounds of milk each. It is possible that with cows of greater or less production different amounts of silage might be fed with varying results as regards intensity of the flavor imparted

to milk. It is believed, however, that the conclusions state fundamentals which will have equal importance under all conditions.

CONCLUSIONS.

There is a wide variation in the flavor and odor of the milk from individual normal cows receiving the same feeds.

While silage-tainted barn air may have some effect on the flavor and odor of milk, it is of relatively small importance under average and even under extreme conditions.

The flavor and odor of silage are largely imparted to milk through the body of the cow.

Silage which is fed one hour before milking is so quickly absorbed that its taint is discernible in the milk.

Silage should be fed immediately after milking.

Not over 15 to 25 pounds of corn silage or 15 pounds of legume silage can be fed twice daily after milking without imparting a discernible flavor and odor to the milk of cows of similar productive capacity to those used in this experiment.

Legume silage affects the flavor and odor of milk to a greater extent than an equal amount of corn silage.

Careful and prompt aeration of the warm milk will permanently remove silage flavors and odors from slightly tainted milk and will reduce the degree of more pronounced silage flavors and odors.

Moderate quantities of corn silage fed after milking and the milk promptly aerated may in some cases actually improve the flavor of milk that would otherwise have a flat or insipid taste.

While silage odors in the barn air have only a slight effect on the flavor and odor of milk, it is best to provide adequate ventilation and exercise other sanitary measures to insure the finest possible flavors.

The feeding of badly decomposed or moldy silage imparts to milk undesirable flavors.

Cream from silage-tainted milk possesses and retains silage flavors and odors to a greater extent than the milk from which it is taken.

Condensed milk made from silage-tainted milk has a less perceptible silage flavor and odor than the milk from which it is made.

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